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Role of Six Sigma in Total Quality Management

Pradyot Deolia[1], Dr. P.L. Verma[2], Dr. Lokesh Bajpai[3]
[1]Research Scholar, Mechanical Engineering Department, S.A.T.I. Vidisha, INDIA
[2] Associate Professor, Mechanical Engineering Department, S.A.T.I. Vidisha, INDIA
[3]Professor and Head, Mechanical Engineering Department, S.A.T.I. Vidisha, INDIA

Abstract - **In the paper is present a Six Sigma project, undertaken within company for production automotive parts, which deals with identification and reduction of production cost in the deburring process for gravity die-casting and improvement of quality level of produced parts. The objectives are achieved by application of Six Sigma approach to quality improvements project in automotive industry. The applied Six Sigma approach includes team works through several phases: Define, Measure, Analyse, Improve and Control (DMAIC). Systematic application of Six Sigma DMAIC tools and methodology within an automotive parts results with several achievements such as reduction of tools expenses, cost of poor quality and labours expenses. It was shown that Six Sigma is an effective way to find out where are the greatest points of the process. Also, six sigma provide measurable indicators and adequate data for analytical analysis.**

Keywords – Quality management; Six Sigma; Capability analysis; Measurement system analysis.

1. INTRODUCTION

Six Sigma is new, emerging, approach to quality assurance and quality management on continuous quality improvements. The main goal of this approach is reaching level of quality and reliability that will satisfy and even exceed demands and expectations of today's demanding customer. A term Sigma Quality level is used as an indicator of process goodness. Lower Sigma quality level means greater possibility of defective products, while, higher sigma quality level means smaller possibility of defective products. If Sigma quality level equals six, chances for defective products are 3.4 ppm. Achieving Six Sigma quality level involves leadership, infrastructure, appropriate tools and methods. In addition, Six Sigma can be integrated with scheduling to create the better environment for good control and continuous performance improvements [Phanden et al. 2011, 2012a, 2013].

The main objective of Six Sigma initiative is to aggressively attack costs of a quality Overall costs of quality are usually divided in tangible and intangible part. The tangible or also said visible part of cost of quality, e.g., like inspection and warranty costs, scrap, rework and reject, can be approximated with only 10-15 % of overall costs of quality. Remaining 85-90 % of quality costs are usually intangible and therefore, overlooked and neglected in companies quality costs analyses. Tools and methodology within Six Sigma deals with overall costs of quality, both tangible and intangible parts, trying to minimize it, while, in the same time, increasing overall quality level contribute to company business success and profitability.

2. LITERATURE REVIEW

Six Sigma is a set of techniques and tools for process improvement. It was developed by Motorola in 1986. Jack Welch made it central to his business strategy at General Electric in 1995. Today, it is used in many industrial sectors.

Six Sigma seeks to improve the quality of process outputs by identifying and removing the causes of defects (errors) and minimizing variability in manufacturing and business processes. It uses a set of quality management methods, including statistical methods, and creates a special infrastructure of people within the organization ("Champions", "Black Belts", "Green Belts", "Yellow Belts", etc.) who are experts in these methods. Each Six Sigma project carried out within an organization follows a defined sequence of steps and has quantified value targets, for example: reduce process cycle time, reduce pollution, reduce costs, increase customer satisfaction, and increase profits. These are also core to principles of Total Quality Management (TQM) as described by Peter Drucker and Tom Peters (particularly in his book "In Search of Excellence" in which he refers to the Motorola six sigma principles).

The term Six Sigma originated from terminology associated with manufacturing, specifically terms associated with statistical modeling of manufacturing processes. The maturity of a manufacturing process can be described by a sigma rating indicating its yield or the percentage of defect-free products it creates. A six sigma process is one in which 99.99966 % below; this defect level corresponds to only a 4.5 sigma level. Motorola set a goal of “six sigma” for all of its manufacturing operations, and this goal became a by-word for the management and engineering practices used to achieve it.

3. ADOPTED METHODOLOGY

A Six Sigma project, which deals with identification and reduction of production cost in the deburring process for gravity die-casting turbo compressor housing, was undertaken within company for production automotive parts. In this project the Six Sigma approach, based on team, works through the structured DMAIC methodology (Define, Measure, Analyze, and Control phases), Figure 1

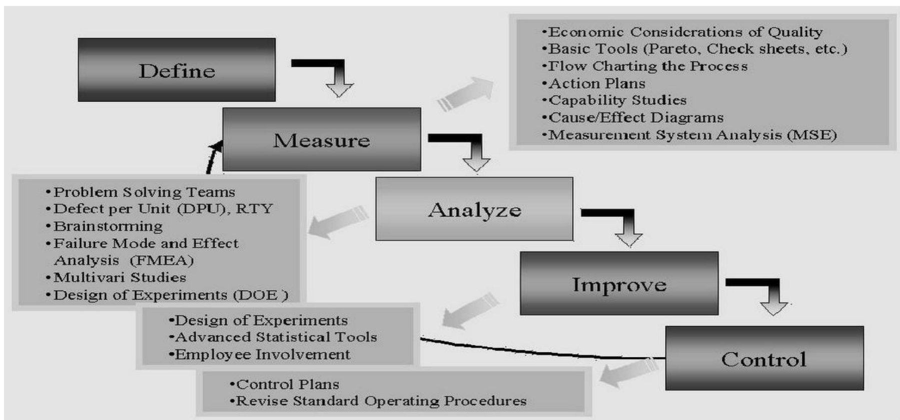

Fig.1. DMAIC methodology for running Six Sigma projects

3.1 Define Phase

Within Define phase are articulated problem descriptions, objectives and as well as solution strategy. The main goal was to identify and decrease expenses in the deburring department for aluminum castings through times and scrap reduction for at least 30 %. There were several major causes for the high expenses variability in castings quality, to many handcrafts, and to long control time.

The main objectives of undertaken projects were to identify areas in the process where extra expenses exist, identify the biggest impact on production expenses, introduce appropriate measurement system, improve process and reduce expenses on production times, and implement improvements.

An adequate metrics for evaluating projects success should be established. These metrics includes ratio volume/cost, labour cost, tool cost, scrap cost, number of nonconforming or defect parts per million (ppm), and Rolled Throughput Yield (RTY), the probability that a part will pass through multiple process steps without a defect.

3.2 Measurement Phase

One of the objectives of project was to identify major process variables impacting the high expenses. Pareto chart for total expenses, Figure 2, shows that the highest impacts has labour costs with 42.6%, following by production centre and headquarter costs, but the last two, as well as production service costs, were successfully reduced with internal system reorganization of company.

Based on Pareto chart, formed team made decision to analyze and make improvements within labour and tools cost area, which together have amount of 48% of total expenses. Also, there were submitted that quality improvement and reduction of quality costs within process are achievable.

The significant improvement could be accomplished by:

- Reduction of cycle time,
- Reduction of control time,
- Reduction of tool costs, and
- Minimizing or eliminating scrap.

The deburring process for compressor housing no. 434.807 was chosen because Pareto diagram showed that the part number have the biggest volume of production, which was 40 % while the first following, has 15 %.

The first undertaken team task was to completion of a thought process map (TMAP), Figure 3. Team approach and idea how to solve the problem was elaborated through the TMAP.

The chosen deburring processes for compressor housing involves following production steps:

- Sawing residual of feeding system,
- Drilling,
- Burrs removal – cleaning bases for clamping on machining area,
- Rough grinding – burrs removal in the dividing plain, and
- Control – material defects and simulation of machining clamping system.

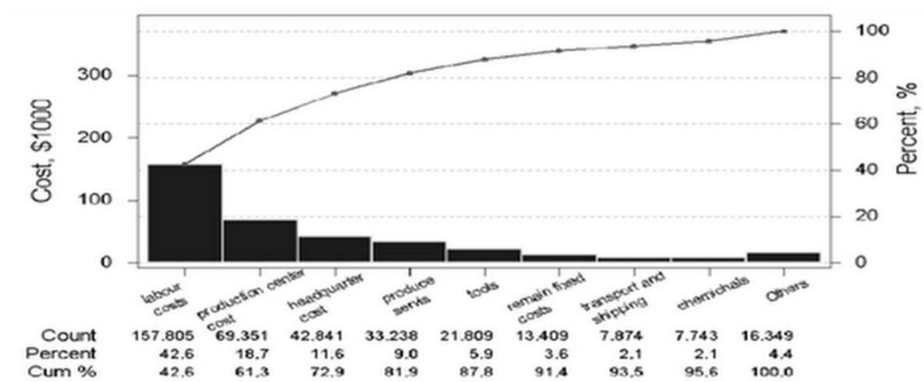

Fig. 2. Pareto chart for total expenses in the deburring department

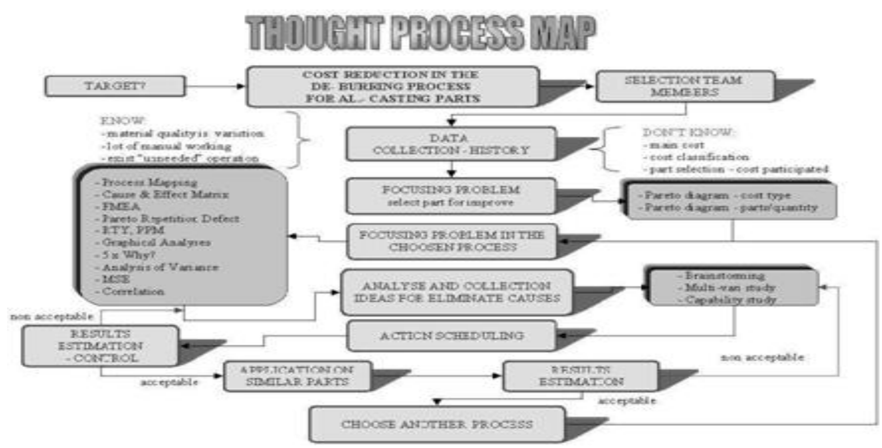

Fig. 3. Thought process map

3.3 **Analyze Phase**

Firstly, FMEA for the deburring process was made. The most critical operations were the control operation and the press operation. Conducted analyze showed that data before press operation were normal distributed while, after operation data were non-normal distribution.

The measurement system analysis for controlling the most important dimension of compressor housing (4, 7 min) with two operator and two trials per operator was conducted. The result showed that operator #1 needs some training, while operator #2 has good measuring results. In addition, the measurement gages are reliable.

The data means were analyzed before and after press operation and results showed that there wasn't significance wasn't smaller than 5 % it was very close (5, 3 %) so obtained result should be taken with care. It was obviously that something affect normality of data during the press operation and, after detailed analyses of all process conditions, it was decided to do additional analysis taking into consideration in the casting parts. Also, additional measurements are made to check influence of burrs size to the variability of part dimensions.

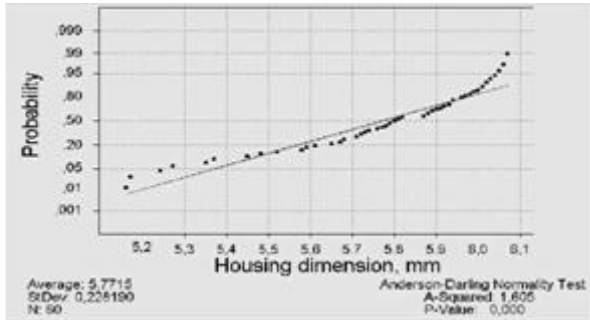

Fig. 4. Normality test for data after Press Operation

3.4 **Improvement Phase**

Through followed brainstorming session decision was made that tool modification is needed to reduce cutting forces and avoid scrap appearance. Modification was applied and significant results were obtained, primarily in scrap and tool wearing reduction. Although, significant improvements were achieved, defined goals were not jet met, so further experimentation where conducted with different clamping system in the machining area.

Obtained results lead the way to make some amendments in the clamping system to avoid or decrease impact of material scrap and automatically decrease scrap expenses. After appropriate tool construction, several experiments with external clamping were done with process capability study and measurement system analysis (Gage R&R analyses), Figure 5.

3.5 **Control Phase**

The analyses results showed that there weren't any significant differences on the critical dimensions, but the most important fact was that the radial accuracy in the defined diameters was unsatisfied. Experiment was repeated with external clamping system, but this time with burr classification, and controlling surface for clamping on parts, Results were analyzed and final decision made about external clamping system application in the machining area.

In this final phase DMAIC methodology, a control plan was developed to ensure that processes and products consistently meets our and customer requirements, and to check how, external clamping system impact on quality production level.

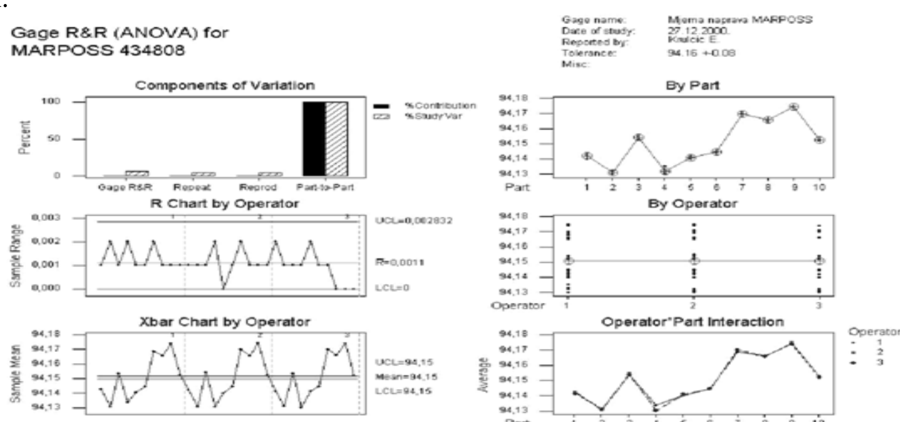

Fig. 5. Measurement system analysis

4. **RESULT AND DISCUSSION**

Six Sigma is an effective way to find out where the greatest process needs are and which the softest points of the process are. Also, six sigma provide measurable indicators and adequate data for analytical analysis.

Systematic application of Six Sigma DMAIC tools and methodology within an automotive parts production results with several achievements. The achieved results are:

- Reduced tool expenses for 40 %,
- Reduced costs of poor quality (CORQ) for 55 %, and
- Reduced labours expenses for 59 %.

  Also, the significant results are achieved by two indexes that are not dependent on the volume of production:
- Production time reduction for 38 %, and
- Index cost/volume reduction for 31 %.

  Generally, improvements through reduced Production time, Control time, Material and Internal scrap will give annual benefits of $ 72 000.

  Expected annual benefits of external clamping system application is $ 100 000.

5. CONCLUSIONS

Conducted improvement project based on Six Sigma methodology provides close acquaintance with all phases of process while Six Sigma tools enables right decisions and the most significant improvements. Besides the appropriate methodology implementation, it is also essentially to develop an infrastructure that will initiate and support Six Sigma projects and initiatives. Definitely, Six Sigma is powerful methodologies that can, properly implemented, result with significances savings and improvements.

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